

PATENT APPLICATION

FUEL ADDITIVE

5

BACKGROUND OF THE INVENTION

Field of the Invention (Technical Field):

The present invention relates to fuel additives which can improve combustion efficiency of any hydrocarbon fuel, thereby increasing the amount of BTUs given off while reducing harmful emissions. The fuel additive can additionally protect a fuel-burning device from scale build-up, improve burn rate, act as a lubricant, stabilize the fuel to prevent repolymerization, disperse macroscopic sludge and provide a biostatic agent to prevent microbial growth.

Background Art:

Note that the following discussion refers to a number of publications by author(s) and year of publication, and that due to recent publication dates certain publications are not to be considered as prior art vis-a-vis the present invention. Discussion of such publications herein is given for more complete background and is not to be construed as an admission that such publications are prior art for patentability determination purposes.

20

Fuel additives have become more and more important to individuals and to industry given the escalating prices of processed oil. As the price of fuel increases, the importance of utilizing every possible BTU accessible in burning fuel increases. Additionally, given the focus over the last two decades on increasing fuel efficiency while lowering emissions, it has become just as important to burn fuel efficiently to reduce emissions, thereby protecting the environment.

25

Other than prior compositions patented by inventor of the present invention in U.S. Patent Nos. 4,585,462 and 4,609,379 to Kitchen, III, prior art compositions and devices have generally been

concerned with improving air quality by one of four basic approaches: pre-combustion removal of contaminants, post-combustion removal of contaminants, use of low sulfur and vanadium fuel oils, and blending fuel oils. The present invention is concerned with a fifth approach, improved combustion of the fuel, thereby giving a two-fold benefit: (1) more energy obtained from a fixed amount of fuel, and (2) less
5 contaminant emissions from the fuel.

U.S. Patent No. 4,609,379 to Kitchen, III discloses a fuel additive for inhibiting polymerization of fuel components comprising a major proportion of a high molecular weight amine and minor proportions of naphtha and a polyalphaolefin synthetic oil, with a small amount of a biocide for use in distillate fuels such as kerosene and diesel fuels in a ratio of about one part additive to about 3,000 to about 10,000 parts of fuel. U.S. Patent No. 4,585,462 to Kitchen, III discloses a fuel additive for improving fuel combustion comprising a major proportion of a high molecular weight amine and minor proportions of a naphtha and a polyalphaolefin synthetic oil, with a small amount of biocide and manganese-containing organometallic compounds to combine in a ratio of about one part additive to about 8,000 parts of fuel.

A fuel additive that seeks to provide the best energy output and least emission output should seek complete combustion of the fuel. This will reduce deposits of carbon residue scale and soot and acid smut emissions. This decreased scale will improve thermal transfer within a fuel utilizing device, thereby increasing efficiency and increasing BTU output. Additionally, the less scale is built up, the less
20 maintenance a fuel-burning device will need.

In order for the most complete combustion of fuel to be obtained, it is best to incorporate a fuel stabilizer within the composition. Fuel begins to destabilize and repolymerize immediately after refining. The longer a fuel is stored, the greater the amount of repolymerization. This results in the formation of
25 submicronic particles that can agglomerate and eventually plug fuel filters and atomizers. Eventually, sludge will form and the fuel will become unpumpable. This phenomenon is especially prevalent with fuel oil utilized for heating systems. Unfortunately, fuel oil line systems are often stand-by systems, thereby allowing the fuel oil to sit unused for lengthy amounts of time, allowing repolymerization to occur.

Many fuel companies will periodically pump and filter the stand-by fuel supplies to remove sludge. As the rate of repolymerization is a direct function of age and energy input into the fuel, this does more harm than good, unless the polymerized agglomerates are depolymerized and dispersed. A fuel stabilizer will help prevent the repolymerization of the fuel that typically occurs during storage.

5

Another problem resulting in repolymerization of fuel is the presence of various microbial strains naturally present within the fuel oil. These bacteria feed on nitrogen, sulfur and iron oxides present in the fuel. The bacteria themselves provide a surface for repolymerization. Therefore, growth of the bacteria result in increased agglomeration. Consequently, it is helpful to provide a biostatic agent within the composition to reduce microbial growth.

10

One problem with the combustion of fuel is the resulting harmful emissions. Automobile engines typically utilize catalytic converters, a large cumbersome device that catalyzes reactions to reduce emissions in the automobile's exhaust gases. A catalytic converter contains small beads that are coated with metals, such as palladium and platinum. When exhaust gases pass through the catalytic converter, these metals act as catalysts, encouraging chemical reactions that change pollutants, such as carbon monoxide and hydrocarbons, into less harmful carbon dioxide and water. Since the 1970s, state and national governments in the United States have passed increasingly stringent emission-control measures. To meet these emission standards, since the early 1980s, all new cars sold in the United States have been equipped with catalytic converters. Additionally, many states require time-consuming routine, sometimes yearly, inspections of these devices. The present invention, unlike prior art fuel additives, may incorporate organometallic compounds that overcome the need to use such a device. This would eliminate the need for the inspections and space taken up by the bulky catalytic converters.

15

20

25

Finally, prior art fuel additives did not contain a dispersant to aid in dispersing particulate matter, thereby preventing and additionally, breaking up agglomerates in fuel. The present invention may contain a dispersant to aid in the prevention and elimination of existing agglomerates.

With the exception of the prior art patents of the inventor, the other art within the industry does not examine improved fuel consumption as a method for reducing pollutants and increasing fuel efficiency. The prior art patents, and the '462 and the '379 Patents, did not provide the best possible utilization of catalytic materials, metal deactivators, or dispersants as does the present invention.

SUMMARY OF THE INVENTION (DISCLOSURE OF THE INVENTION)

Fuel additives of the current invention comprise a stabilizer and an organometallic compound for catalysis. Additionally, it is preferred that a dispersant is provided. Other compounds may be utilized in the composition, including a high flash solvent, a lubricant, a biostatic agent, and a metal deactivator. The composition is utilized at a ratio of from approximately 1000 to approximately 10,000 parts by volume of fuel to approximately one part of composition. It is preferred that one part of composition be applied to approximately 5000 parts by volume of fuel.

A primary object of the present invention is providing a fuel additive that prevents repolymerization of fuel components.

Another object of the present invention is providing a fuel additive that facilitates more complete combustion of the fuel.

Yet another object of the present invention is providing a fuel additive that undergoes catalytic conversion of by-products of combustion to render the by-products harmless.

Another object of the present invention is to prevent formation of agglomerates in fuel.

Another object of the present invention is to provide a fuel additive which allows a fixed amount of fuel to produce a higher BTU output.

Yet another object of the present invention is to provide a fuel additive which decreases harmful emissions.

5 Another object of the invention is to provide a fuel additive which prevents scale formation on engine components.

A primary advantage of the present invention is the increased BTU output and decreased harmful emissions output.

Another advantage of the present invention is the reduced agglomerations and sludge within a fuel supply.

Another advantage is the ability to store fuel long-term without agglomeration formation.

Other objects, advantages and novel features, and further scope of applicability of the present invention will be set forth in part in the detailed description to follow, and in part will become apparent to those skilled in the art upon examination of the following, or may be learned by practice of the invention. The objects and advantages of the invention may be realized and attained by means of the
20 instrumentalities and combinations particularly pointed out in the appended claims.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

(BEST MODES FOR CARRYING OUT THE INVENTION)

25 Fuel additive compositions of the present invention comprise a fuel stabilizer and an organometallic compound for catalysis. It is preferred that a dispersant is provided. Other compounds may be utilized in the composition, including a high flash solvent, a lubricant, a biostatic agent, and a metal deactivator. The composition may be applied to multiple fuel types, including but not limited to fuel oils and gasoline.

A stabilizing agent is provided to prevent repolymerization of the hydrocarbons in the fuel. Repolymerization of hydrocarbons begins immediately after the fuel is refined. As the repolymerization occurs, submicronic particles agglomerate and eventually result in sludge formation. Even the smaller
5 particle agglomeration may result in clogging of filters. A high molecular weight amine which is the preferred stabilizing agent, prevents such repolymerization. The amine has added benefits of acting as a detergent, dispersant, and emulsifier. Additionally, it acts as a corrosion inhibitor to prevent iron (which can be present both naturally in the fuel or as part of the invention as the organometallic compound) from oxidizing. This has a side benefit of inhibiting bacteria (naturally present in the fuel) from feeding on
10 nitrogen, sulfur, and iron oxides in the fuel.

The high molecular weight amine of the invention preferably contains at least twelve carbons. More preferably, it contains approximately twelve to approximately fourteen carbons. However, it may contain more than fourteen carbons. Most preferably, the amine utilized comprises Primene® RB-3 fuel
15 additive (Rohm and Haas Co., Philadelphia, PA) containing t-alkyl primary amines.

The high molecular weight amine of the present invention preferably comprises between approximately 0.05 and approximately 0.5 parts by weight where the fuel additive has a total part by weight of 1. The amine more preferably comprises between approximately 0.2 and approximately 0.5
20 parts by weight, and most preferably comprises 0.46 parts by weight of the total composition.

The organometallic compound of the composition effectively acts as a catalytic converter, utilizing the metal of the compound as a catalyst to react with carbon monoxide and hydrocarbons. The reaction leaves harmless carbon dioxide and water as products. This reduces emissions of the by-products of
25 combustion, unburned hydrocarbons and carbon monoxide.

The organometallic compound utilized is preferably iron. Manganese, platinum, and cerium may also be utilized separately, mixed, or mixed with iron. When iron is the organometallic compound, it is

preferred that dicyclopentadienyl iron is used. Dicyclopentadienyl iron is commonly known in the industry as Ferrocene (Aldrich Chemical Co. "Sigma-Aldrich"). Additionally, homologues of dicyclopentadienyl iron may be provided as the organometallic compound.

5 The organometallic compound of the present invention preferably comprises between approximately 0.0001 and approximately 0.1 parts by weight of the total composition. The organometallic compound more preferably comprises between approximately 0.001 and approximately 0.005 parts by weight of the total composition, and most preferably, comprises 0.0034 parts by weight of the total composition.

10 The dispersant of the present invention disperses particulate matter, thereby preventing agglomerates from forming and additionally, acting to break up existing agglomerates. It is preferred that the dispersant be a polymer, more preferably that it be a copolymer, and most preferably, that it be an acrylic copolymer. An oil solution of an acrylic polymer that is preferred is Viscoplex® 6-917 (RohMax USA, Inc., Horsham, PA).

15 The dispersant of the present invention preferably comprises up to approximately 0.2 parts by weight of the total composition. The dispersant more preferably comprises between approximately 0.5 and approximately 0.15 parts by weight, and most preferably comprises approximately 0.1 parts by
20 weight.

25 The high flash point solvent of the present invention is provided to diffuse the stabilizer compound in the composition efficiently enough to provide a depolymerization function. A high flash point solvent is a solvent with a flash point from approximately 140°F to approximately 200°F. It is preferred that the high flash point solvent utilized comprises naphtha, and more preferably, that the solvent comprises Conosol® C-145 (Penreco, Houston, TX). Conosol® C-145 is an aliphatic solvent that is composed primarily of C₁₀-C₁₃ cycloparaffinic and isoparaffinic hydrocarbons. It is a low toxicity product that

contains less than 0.5% aromatics, and it has a higher solvent strength than competitive high flash aliphatic solvents.

The high flash point solvent of the present invention preferably comprises between approximately 0.1 and approximately 0.6 parts by weight of the total composition. The solvent more preferably comprises between approximately 0.2 and approximately 0.4 parts by weight of the total composition, and most preferably it comprises approximately 0.3556 parts by weight of the total composition.

The high flash point solvent has a strong solvent action, therefore, it is preferred to use a lubricant when the composition contains the solvent. However, a lubricant may be provided even in the absence of the solvent. The lubricant utilized will help provide the required lubricating properties for operation of diesel generators, pumps, and the like. It is preferred that a mineral oil or a synthetic oil be provided as the lubricant. When a mineral oil is utilized, it is preferred that the oil be naphthenic, not parathenic. It is further preferred that when a synthetic oil is utilized, that the oil be a petroleum derivative, such as an aliphatic hydrocarbon based synthetic oil. Additionally, it is most preferred that the lubricant utilized maintain a low viscosity, preferably 20 weight or less. A preferred synthetic oil is Shellflex® 3271, a petroleum hydrocarbon, highly refined oil in a hydrotreated heavy naphthenic distillate solution.

The lubricant of the present invention preferably comprises between approximately 0.01 and 0.25 parts by weight of the total composition. The lubricant more preferably comprises between approximately 0.03 and approximately 0.1 parts by weight, and most preferably comprises approximately 0.5 parts by weight.

A biostatic agent, or biocide, may be used in the present invention to inhibit the presence and growth of bacteria growing in the fuel. Any biostat may be employed, but it is preferred that a triazine be used to avoid polymerization. It is more preferred that Vancide® TH be used. Vancide® TH is a hexahydro-1,3,5-triethyl-s-triazine.

The biocide of the present invention preferably comprises up to approximately 0.02 parts by weight of the total composition. The biocide more preferably comprises between approximately 0.0005 and approximately 0.0015 parts by weight, and most preferably approximately 0.001 parts by weight of the total composition.

5

Finally, a metal deactivator may be utilized in the present invention. The deactivator coats the inside of a fuel tank and other related parts to prevent corrosion of the steel or other metals. The deactivator is preferably a diamine, more preferably an ethylene diamine or a propane diamine. Octel America, Inc. (Newark, DE) makes a metal deactivator that may be utilized in the invention which provides a N,N' disalicylidene-1,2 propane diamine.

10

The metal deactivator of the present invention preferably comprises up to approximately 0.2 parts by weight of the total composition. The metal deactivator more preferably comprises between approximately 0.05 and approximately 0.15 parts by weight, and most preferably approximately 0.1 parts by weight.

15

The present invention comprises the stabilizer and an organometallic compound, preferably iron. It is preferred that the dispersant also be provided. More preferably, the high flash point solvent, the lubricant, the biocide, and the metal deactivator are also provided. The composition of the present invention is preferably utilized in a ratio of approximately one part by volume of the fuel additive composition to approximately 5000 parts by volume of fuel. However, the composition may be effectively utilized in ratios of from approximately 1000 parts by volume to approximately 10,000 parts by volume of fuel to approximately one part by volume of the composition.

20

25

Industrial Applicability:

The invention is further illustrated by the following non-limiting examples.

Example 1

Testing was done on the composition of the present invention with two locomotives of the Norfolk Southern Railroad over a roughly two month period. One of the locomotives, designated NS 3236 showed a 1.156% improvement in fuel efficiency over this time period. The other engine, designated NS 7041, did not show an improvement. However, this locomotive had not reached a minimum of operations time to allow the composition of the present invention to break down and remove carbon inside the engine. The locomotive was fueled only six times throughout the duration of the test.

Initial readings were taken for a carbon mass balance procedure from the locomotives at the beginning of the test. Number 2 off-road diesel fuel was used exclusively throughout test evaluation. Each engine was brought up to stable operating temperatures as indicated by the engine exhaust temperature. No measurements were taken until stabilization. An SGA-9000 (Sun Electric) non-dispersive, infrared analyzer (NDIR) was used for measuring the exhaust gas constituents for determination of unburned hydrocarbons as hexane gas (HC), CO, CO₂, and O₂.

A carbon mass balance test was performed on the locomotives. The test recognizes the amount of carbon effluents leaving via the exhaust, not the amount of fuel entering the engine. The carbon entering the engine in the fuel is in the form of liquid hydrocarbons (C_xH_x). The carbon leaving the engine is mainly in the form of carbon dioxide (CO₂), carbon monoxide (CO), and unburned hydrocarbons (HC). Therefore, by measuring the rate at which carbon is exiting the exhaust stack, it is possible to state the rate at which it is entering the combustion chamber. By knowing the carbon/hydrogen composition of the fuel and its density it is then possible to state the rate at which fuel is being consumed.

To measure the amount of carbon leaving the engine, the following measurements were made:

- (1) Temperature and pressure--determined by measuring the equivalent volumetric flow rate at standard temperature and pressure conditions;
- (2) Exhaust gas volumetric flow rates--determined by measuring the exhaust's velocity with a pitot tube; and
- (3) Mass per unit volume of components containing carbon--

determined by measuring the volume fractions of CO₂, CO, and HC and converting these to masses.

(Carbon particulate can be included but represent a small fraction of total carbon flow.)

All these measurements were accomplished by inserting a probe into the end of the exhaust
5 stack. These measurements were conducted several times per vehicle to ensure stability, accuracy and
reproducibility. The measurements were conducted at the beginning of the test to form a baseline and
then again at the end of the test after several hundred hours of operating time with usage of the
composition of the present invention.

10 Measurements of exhaust pressure and temperatures, ambient temperatures, barometric
pressures, fuel specific gravity, and exhaust emissions were made along with records of engine types
and sizes, exhaust stack diameter, odometer, hub and/or hour readings in order to perform appropriate
calculations where engine speed and load were duplicated in each test.

15 To calculate the improvement in an engine's performance with the use of the product,
measurements were made with the engine running at a stabilized RPM and temperature using untreated
fuel (baseline measurements) and treated fuel (treated measurements). Improvements are stated as
percentage changes from baseline. Any absolute errors which arose in the calculation of fuel
consumption will not affect the comparison figures since the errors will be of the same magnitude for the
20 baseline and treated measurements.

From the exhaust gas concentrations measured during the test, the molecular weight of each
constituent, the exhaust volume and the temperature of the exhaust stream, the fuel consumption was
expressed as a "performance factor" which relates the fuel consumption of the treated fuel to the
25 baseline. The calculations were based on the assumption that the fuel characteristics, engine operating
conditions and test conditions were essentially the same throughout the test.

These measurements were converted to the amount of carbon (fuel) entering the system. The advantage of using this method is that an engine can be loaded as accurately as possible and many operating variables such as climatic conditions, load, tire pressure, driver and gradient changes can be eliminated.

5

After the baseline test, the fuel storage tanks on the locomotive were treated, from a tank added on board, at the recommended level of one ounce of the composition to forty gallons of diesel fuel (1:5000 volume ratio). The vehicles were then operated with the treated fuel as normal. After the testing time elapsed, the test procedure was duplicated for the treated portion of the evaluation.

10

Throughout the entire fuel consumption test, an internal self-calibration of the exhaust analyzer was performed after every two sets of measurements to correct possible instrument drift. A new exhaust particulate gas filter was installed before the baseline and treated fuel test series.

15

Each locomotive was tested under steady-state conditions at stabilized RPMs. Table 1 summarizes test results based on fuel economy, showing an average of 2.12% improvement over the duration of the test.

20

TABLE 1

Unit No. 3236	Engine	RPM	Overall % Improvement
RUN #1	645-E3C	681.2	1.72%
RUN #2	645-E3C	678.2	2.01%
RUN #3	645-E3C	677.8	2.36%
RUN #4	645-E3C	677.8	2.42%
RUN #5	645-E3C	682.2	2.57%
RUN #6	645-E3C	679.8	2.61%
RUN #7	645-E3C	690.0	2.84%

A qualitative smoke reduction test was performed during the testing. This was done by attaching a 25 micron filter to the exhaust gas sampling train for each test. The filter trapped unburned fuel

exhausted from the engine as visible smoke or particulate. A new filter was installed at the beginning of each test.

CO and HC levels are related to cleanliness of burn, while CO₂ levels are related to rate of burn.

- 5 Therefore, with a decrease in CO and HC it can be gathered that the fuel is being burned cleaner. On the other hand, with the reductions of CO₂ levels, the efficiency of fuel usage increases. Table 2 illustrates the reductions in emissions over the duration of the testing, clearly demonstrating a reduction in harmful emissions.

TABLE 2

UNIT #3236	CO	HC	CO ₂	O ₂
RUN #1	-38.89	-41.02	-2.6	-7.5
RUN #2	-36.84	-42.86	-2.7	-7.2
RUN #3	-35.29	-39.47	-2.7	-7.3
RUN #4	-33.33	-42.11	-2.5	-6.9
RUN #5	-29.41	-41.18	-2.8	-7.5
RUN #6	-31.25	-44.0	-2.3	-7.4
RUN #7	-37.5	-41.67	-2.2	-7.6

Example 2

- 15 Testing was performed on the composition of the current invention for comparison with the composition of the prior art '462 patent. It was found that the composition of the '462 patent did not provide stabilization of the fuel for prevention of agglomerate formation comparable to the stabilization provided by the composition of the present invention.

- 20 Three samples of approximately 7.5 to 8.0 ml were taken containing a fuel sample. The composition of the '462 patent was added to one sample at a 1 to 10,000 composition to fuel ratio. The composition of the present invention was added to a second sample at a 1 to 10,000 composition to fuel ratio. A third blank sample containing only the fuel source was also prepared and the total volumes of sample equalized.

Each sample was heat stressed at 300°F for approximately 10 minutes, then allowed to cool for approximately 10 minutes. The heat stress is a simulation for accelerated aging of the sample. The heat catalyzes repolymerization of the fuel, thereby simulating aging. Normally, the fuel would be stored in underground tanks at approximately 55°F over a period of years.

5

An ultraviolet spectrophotometer was used to provide an initial optical reading on each sample tube. The readings were taken at 572 nanometers, in the visual range. Measurements are optical units indicating opacity of the sample, the higher the number, the greater light transmittance indicating a lower opacity. Error was calculated to +/- 2 optical units.

The testing showed a change in opacity for the blank fuel test tube of 27 optical units (o.u.), having an initial reading of 48 o.u. and an end reading of 21 o.u. The '462 composition showed a change in opacity of 24 optical units, having an initial reading of 50 o.u., and an end reading of 26 o.u. The composition of the present invention showed a change in opacity of 5 optical units, having an initial reading of 48 o.u., and an end reading of 43 o.u. The ΔT , or change in transmission, showed only a minor change in the composition of the present invention. More drastic changes occurred in the compositions of the '462 and blank tests, indicating agglomerations within the fuel in those samples.

The preceding examples can be repeated with similar success by substituting the generically or specifically described reactants and/or operating conditions of this invention for those used in the preceding examples.

Although the invention has been described in detail with particular reference to these preferred embodiments, other embodiments can achieve the same results. Variations and modifications of the present invention will be obvious to those skilled in the art and it is intended to cover in the appended

[illegible]